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BIOLOGICAL BULLETIN

THE NESTS AND LARVÆ OF NECTURUS.

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THE NESTS.

1. *Nests in a Lake Habitat.*—Through the courtesy of Professor Bennet M. Allen I recently became acquainted with the spawning grounds of *Necturus maculosus* Rafinesque in Lake Monona, Wis. During the latter part of June and the early part of July, 1910, several trips were made to the locality for the purpose of obtaining embryological material.

The "nests" were found in water about 3–5 feet deep and about 50–100 feet from the shore, in a locality where the bottom was strewn with loose flat stones of various sizes. The largest of these stones, about 1½–2 feet in diameter, frequently served as cover for the eggs of *Necturus*. The eggs are attached by the slender stalks of the gelatinous envelopes singly to the under sides of these stones, distributed over an area about 8–10 inches in diameter (see Fig. 1). The presence of minute algæ, etc., in the water made it so opaque that it was impossible to see the bottom; the eggs were obtained by wading in the water, feeling about with the feet for a large flat stone, then bringing it to the surface.

Eycleshymer ('06) describes nests of eggs attached to the under sides of logs, boards, pieces of tin, canvas, etc., but does not mention finding nests under stones. Doubtless any convenient object may be selected as cover.

The number of eggs present in a nest was determined in five cases as follows: 18, 61, 80, 84, 87. The average is 66. The nest photographed contained 84 eggs.

The first embryos were obtained on June 22; these were in an advanced stage of development, with head well formed and a

small tail rudiment. The latest embryos were collected on July 5; at this time nearly all the embryos had hatched, only a few unhatched embryos being found in each of several nests. The empty capsules remained attached by their stalks.

Eycleshymer ('06) states: "The time of egg-laying varies in different lakes, depending upon the time when the temperature

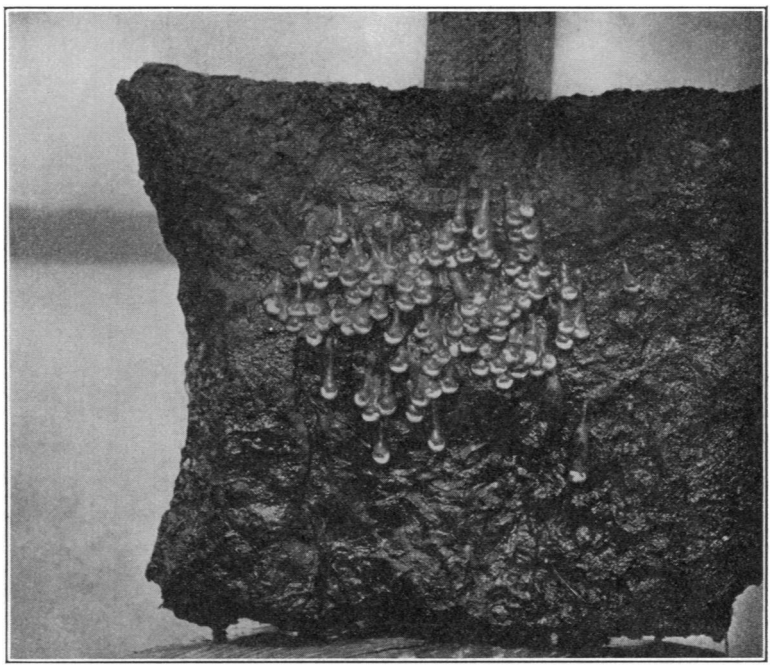

FIG. 1. "Nest" of eggs of *Necturus*. The stone to which the eggs are attached has been removed from the water and set on edge on the wharf; it is about 16 inches in diameter. The embryos are in an advanced stage of development.

of the water reaches a certain degree. In the larger, deeper lakes with bold shores this is much later than in those possessing wide shoals. . . . According to Professor Whitman's and my own experience the best time for collecting is during the middle and latter parts of the month of May. The writer has collected eggs as early as May 3, and as late as June 5, but these extremes mark the beginning and closing of the early and late seasons." Unless the dates given are for *newly-laid* eggs, which would

hardly be inferred from the text, my experience shows that the collecting season may be much later than Eycleshymer recorded.

A noticeable feature of the development as compared with other amphibians that I have studied, is the uniformity in the stage of development of embryos found in different nests in the same locality. On each of the following dates from four to seven nests were secured: June 22, 25, 29, July 5. On each date all the eggs were found so nearly in the same stage of development that only slight differences could be detected in eggs from different nests. This uniformity points to a very short spawning season—perhaps two or three days—in this locality; it would seem that all the eggs in a restricted area are laid at nearly the same time. But Eycleshymer ('06) says: "The eggs are first deposited in those localities where the water is shallow and exposed for the greater part of the day to the rays of the sun. The period of egg-laying usually covers two or three weeks. There is no foundation whatever for the statement made by Hans Virchow that the animals deposit their eggs so to speak at the same hour."

I had no success in keeping embryos of *Necturus* alive in the laboratory, although later in the year larvæ of *Cryptobranchus* thrived under the same conditions.

2. *Nests in a Stream Habitat.*—I am not aware of any published observations on the nesting of *Necturus* in streams, hence the following notes on the subject may be of interest.

During the late summer and early autumn of the past five years, while searching for adults, eggs and larvæ of *Cryptobranchus*, I have had occasion to overturn numberless stones in the bottom of a large creek tributary to the Allegheny River, in northwestern Pennsylvania. This has resulted in the frequent finding of specimens of *Necturus*.

All the specimens found were small, none exceeding 20 cm. (8 in.) in length and most of them were much smaller. The smallest, taken September 13, 1906, was 35 mm. long (see Fig. 6). This specimen was one of a group of six or seven found under the same stone; the others, aided by the swift current, escaped.

These circumstances led me to suspect that the stream was a spawning ground for *Necturus*. This suspicion received confirmation when, on August 24, 1910, I found attached to the

under side of a large rock about fifteen or twenty empty egg capsules of *Necturus*, all in good condition. At the distal end of each capsule was a large round hole through which the embryo had escaped.

The Larvæ.

1. *The Embryo at the Time of Hatching.*—Fig. 2 is from a photograph of an embryo of *Necturus* obtained from Lake Monona on July 5, 1910. This embryo was apparently ready to hatch, since nearly all the other embryos in the nest had already hatched out.

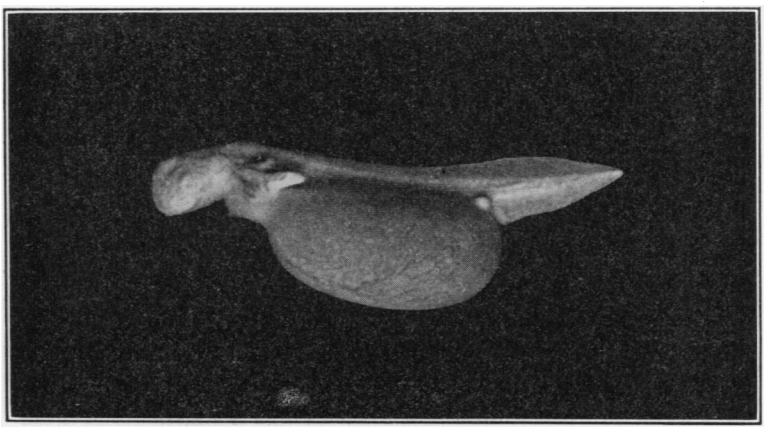

Fig. 2. *Necturus* embryo ready to hatch, killed in Tellyesnicky's fluid and preserved in formalin, July 5, 1910. (× 3½.) From Lake Monona.

The embryos of *Necturus* are hatched in a less advanced stage of development than is the case with *Cryptobranchus* (see Smith, '07, Fig. 9); but in *Cryptobranchus* at least there is considerable variation in the time of hatching and the figure referred to represents one of the more advanced of the newly-hatched embryos, hence the difference may be less than the figures indicate. *Necturus* is hatched in water of a much higher temperature than is the case with *Cryptobranchus*, and this would naturally tend to soften the gelatinous envelope and aid in the early escape of the embryo.

In *Necturus* the large yolk content at the time of hatching is even more noteworthy than in *Cryptobranchus*. Though set

free as a larva, the animal is really in an embryonic state so far as its food supply is concerned, until long after its liberation. The only advantages secured by hatching in this condition would seem to be better aeration and opportunities for exercise; these advantages must be in part offset by the increased danger of capture by some larger animal.

Aside from differences in the stage of development, the embryos of *Necturus* and *Cryptobranchus* at about the time of hatching are so much alike that it would be difficult to tell them apart were it not for the noticeably greater bulk of the latter. At the

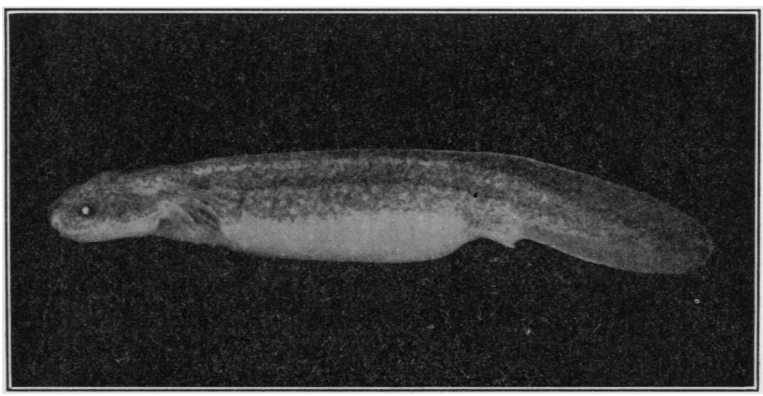

FIG. 3. *Necturus* larva reared from advanced embryo obtained from Lake Monona, and preserved in formalin July 31, 1910. (× 3½.)

time of hatching the *Necturus* embryo measures about 18 mm. in length, the *Cryptobranchus* embryo about 24 mm.; this difference may be due in part to the more advanced condition of the latter, but throughout the entire embryonic history the size of embryos of corresponding stages is so much greater in the case of *Cryptobranchus* that though eggs from different nests of the same species may vary slightly in size, the extremes of variation of the two species do not overlap.

2. *Larval Development.*—I have examined a series of early larval stages kindly loaned me for the purpose by Dr. Bennet M. Allen. The series comprises twelve specimens raised from advanced embryos obtained from Lake Monona and preserved in formalin on the following dates: July 31, August 19, 21, 25, 1910.

Specimens preserved July 31 (see Fig. 3) average about 25 mm. long. As compared with *Cryptobranchus* larvæ of the same age after hatching, in *Necturus* the general form of the body is more slender, except that the yolk sac is of relatively greater size. The absolute size of the *Cryptobranchus* larva is much greater. The pigmentation in *Necturus* is less intense, and the general appearance is that of a less advanced stage of development.

These specimens show the beginning of the dorso-lateral stripes, which attain great prominence in later stages and will be described in the stage in which they are most marked.

In the larvæ preserved during the latter part of August, the yolk sac still persists, though its size is so reduced that the abdomen is only slightly distended by it. The lateral stripes are quite distinct, though not so conspicuous as in slightly later stages. The larvæ average about 30 mm. in length. In *Cryptobranchus* larvæ of the same age after hatching, the yolk sac is so reduced that the abdomen is no more distended than in the adult; the color is much darker than in *Necturus*, the form of the body stouter, and the absolute size nearly twice as great.

For a larval specimen 34 mm. long, I am indebted to Mr. L. W. Harrington, formerly an assistant in the Zoölogical Laboratory of the University of Michigan. This specimen was obtained by Mr. Harrington from fishermen in the Detroit River on November 24, 1906, and was examined by me on the same day, before preservation. The transparency of the ventral abdominal wall enables one readily to note that the yolk has been entirely absorbed. Since the coloration conforms accurately to that of the Lake Monona specimens, a description of the color pattern will serve for all the western larvæ examined by me.

As contrasted with the adult, the most striking feature of the 34-mm. larva is the presence of a conspicuous dorso-lateral longitudinal stripe, light yellow in color, on each side of the body. The lateral margin of each stripe is metamerically crenate. The body stripes continue unbroken and without fusion to the tip of the tail; anteriorly, they are separated by a slight break from similar stripes along the margin of the dorsal surface of the head; these latter are sometimes connected at their anterior ends by a faint transverse bar over the tip of the snout.

The ground color of the dorsal and lateral surfaces is a dark brown, with small scattering spots of lighter color especially noticeable along the sides of the body and tail. As compared with the earlier stages the pigmentation is much more intense, but this merely serves to accentuate the light-yellow stripes. It is to be particularly noted that in all the western larvæ that I have examined, the dark color of the dorsal surface of the body is continued along the dorsal edge of the tail between the lateral stripes (see Fig. 4). The ventral surface is pale yellow, almost transparent.

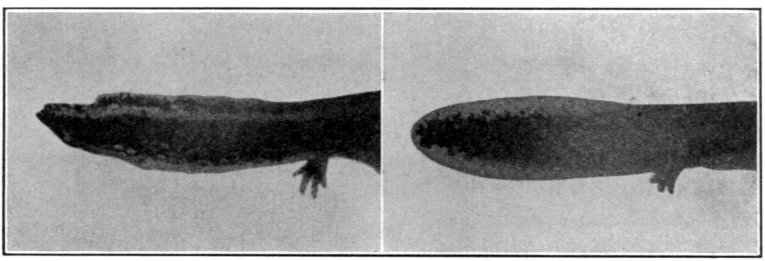

FIG. 4. FIG. 5.

FIG. 4. Caudal portion of a 34-mm. *Necturus* larva taken from the Detroit River, showing color pattern of the tail. The specimen is somewhat shrivelled from partial drying before preservation; in particular the ventral margin of the tail is upturned. Photographed after preservation in formalin. (× 3½.)

FIG. 5. Caudal portion of a 35-mm. larva of *Necturus* taken from a stream in northwestern Pennsylvania, showing color pattern of the tail. Photographed from a formalin specimen. (× 3½.)

Mention has already been made of larvæ taken from a stream habitat in northwestern Pennsylvania. No attempt was made to capture all the specimens found, but a series was preserved representing a gradation in size from the smallest, 35 mm. long, to the largest, 20 cm. in length. Of these the fourteen smallest, all under 15 cm. in length, show larval characteristics in the color pattern.

The smallest specimen, 35 mm. in length (see Fig. 6), was taken on September 13, 1906. This larva is younger and morphologically less advanced than the slightly smaller larva obtained from the Detroit River; but on account of an important difference in the color pattern its description has been deferred.

By dissection it was found that the yolk sac, though reduced almost to the form of a digestive tube, still contained a small amount of yolk. Assuming that this larva had been hatched about 8–10 weeks, we find a similar condition of the yolk sac in *Cryptobranchus* larvæ of the same age after hatching.

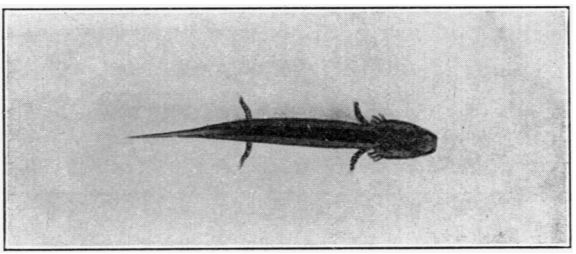

FIG. 6. Living larva of *Necturus*, 35 mm. long. ($\times\frac{7}{8}$.)

This specimen differs from the western larvæ in that the dorso-lateral stripes unite in the median line at the base of the tail, to be continued as a single stripe along the dorsal edge of the tail (see Fig. 5). Since this peculiarity is present in all the fourteen larvæ that I have examined from the eastern habitat, it would appear to be a constant difference between the eastern

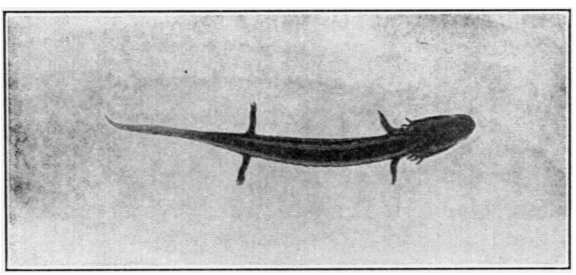

FIG. 7. Larva of *Necturus*, 55 mm. long, photographed after preservation in ormalin. Nearly actual size.

and western forms. Otherwise the color and color pattern of both eastern and western larvæ are the same.

The larger specimens may be described as follows: A 42-mm. larva taken on August 29, 1907, differs morphologically from the 35-mm. larva in its slightly greater yolk content; evidently it is younger, though of greater size. A specimen 55 mm. long

(Fig. 7), taken on August 20, 1906, agrees in its color and color pattern with the 35-mm. larva; the yolk has been entirely absorbed. Another 55-mm. larva taken September 13, 1906, is in the same condition. A 60-mm. specimen taken August 19, 1910, shows a slight loss in the distinctness of the stripes.

The striped pattern characteristic of the larvæ reaches its culmination in specimens of about 55 mm. body length. From this time on it gradually disappears, the light yellow stripes being obscured by dark pigment; during the same period the large black spots, which give the mottled appearance to the color pattern of the adult, become established. With the attainment of a body length of 15 cm. the larval color pattern is entirely replaced by that of the adult. Several specimens with a body length of 20 cm. were dissected and found to be sexually mature.

Eycleshymer ('06), after describing the variation in color of the adult, continues: "It is probable that these variations in color are responsible for a number of specific names. As an instance I might state that some years ago Dr. Garnier ('88) described a small *Necturus*, taken from the Maitland and Lucknow Rivers in Ontario, to which he gave the name *Menobranchus lateralis*, var. *latastei*. 'The coloration above was black, the abdomen sooty and the gular fold white.' During the summer of 1904 the writer was fortunate enough to secure two young animals which measured about 4 and 6 inches respectively. The smaller corresponds closely to the description given by Dr. Garnier and there is every reason for believing that the animal in question is the young of *Necturus maculosus*. The older of the two presents the general coloration of the adult. That *Necturus* should undergo such striking changes in color may appear remarkable to one who has not studied the early stages but when one has followed the changes in color pattern during growth he finds that they are no less striking and remarkable than in the birds."

While I do not doubt the evidence of great variability in the color and color pattern during growth, furnished by those[1]

[1] In a letter from Dr. Whitman to the writer, dated April 22, 1907, he says: "I have reared *Necturus* from the egg, and I can assure you that now and then a single dark *brown* individual is found among the striped ones. I raised one from the egg, and have had two captured by net. They are rare, but are unquestionably *Necturus* in the cases mentioned."

who have reared *Necturus* from the eggs, the fact remains that in all the specimens studied by me not a single non-striped larva has been found, nor is any specimen really black. Moreover, I would point out that Dr. Garnier's description above quoted would make an excellent account of the coloration of a year-old larva of *Cryptobranchus allegheniensis*, having external gills and with a body length of 8 cm.

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